

# Referral Pattern and Timing of Repair Are Risk Factors for Complications After Reconstructive Surgery for Bile Duct Injury

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**Background:** The aim of the present study was to assess the role of the referral pattern and the timing of the surgical procedure on outcome after reconstructive surgery for bile duct injury (BDI).

**Summary Background Data:** BDI after laparoscopic cholecystectomy remains a major problem in current surgical practice. Controversy exists about the influence of previous interventions before referral and the timing of repair on outcome.

**Methods:** Of 500 patients referred to a tertiary center, 151 patients (30.2%) underwent reconstructive surgery for BDI. The influence of referral pattern was analyzed by defining patients as primary and secondary referred patients. The influence of timing of repair was investigated by categorizing 3 groups of patients: A, acute repair; B, delayed repair; and C, late repair.

**Results:** Hospital mortality was zero. Perioperative complications occurred in 29 patients (19.2%): in 26.4% in secondary referred patients and 7.9% in primary referred patients ( $P = 0.04$ ). Perioperative complications occurred in group A in 33.3%, in group B in 15.6%, and in group C in 22.5% ( $P = 0.22$ ). Postoperative strictures occurred significantly more often in patients operated in the acute phase ( $P < 0.01$ ) and in secondary referred patients ( $P = 0.03$ ). A multivariate analysis identified 3 independent negative predictive factors for outcome: extended injury in the biliary tree (odds ratio = 3.70; confidence interval, 1.32–10.34), secondary referral (odds ratio = 4.35; confidence interval, 1.12–16.76), and repair in the acute phase after injury (odds ratio = 5.44; confidence interval, 1.2–24.43).

**Conclusions:** Reconstructive surgery for the treatment of BDI is associated with acceptable morbidity and no mortality. Extended injury to the bile duct, referral to a tertiary center after therapeutic interventions, and acute repair are independent negative predictors on outcome after reconstructive surgery for BDI.

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Bile duct injury (BDI) after laparoscopic cholecystectomy (LC) remains a major problem in current surgical practice. BDI is associated with poor survival, increased morbidity, and impaired quality of life.<sup>1,2</sup> The incidence ranges from 0.3% to 1.4%<sup>3–7</sup> and depends on the study population and the criteria used to define the injury. In the Netherlands, approximately 15,000 LCs are performed annually.<sup>8</sup> As a result, around 50 to 150 patients will suffer from a serious biliary complication per year. Although it has been suggested that the incidence has been stabilized or declined at the end of the learning phase, still 35 to 40 patients are referred annually to our center without any sign of decrease over the last years. BDI requires a multidisciplinary approach by surgeons, gastroenterologists, and interventional radiologists. Cystic stump leakage, partial laceration of the bile duct, and even strictures can be successfully treated by endoscopic retrograde, or percutaneous stenting and dilatation.<sup>9–11</sup> The most severe lesions such as bile duct transection or recurrent strictures generally need reconstructive surgery. However, the optimal surgical strategy in BDI is still debated.<sup>12,13</sup>

Although outcome has been reported excellent after surgical repair in major institutions,<sup>12–15</sup> survival was relatively poor from a nationwide cohort of patients from the United States.<sup>1</sup> Therefore, the referral pattern and the timing of referral might substantially effect the outcome after reconstructive surgery; however, this is only spuriously been investigated.

Another point of controversy is the debate on the timing of the surgical reconstruction. Surgical reconstruction within 12 to 96 hours after the occurrence of the injury can be performed safely in experienced hands. However, a reconstruction performed several days or a few weeks after the injury, on nondilated bile ducts due to leakage and in particular an inflamed hepatoduodenal ligament with abscess formation, is more difficult and associated with more complications.<sup>12</sup> In 2 recent series, an effect of timing of repair on outcome could not be shown, the authors however frequently used interventional radiology to control sepsis and treat biliary fistula and used an interval period to allow inflammation to subside before reconstruction.<sup>13,16</sup>

The aim of the present study is therefore to analyze the outcome after reconstructive surgery for BDI and in particular the influence of referral pattern and timing of repair.

## PATIENTS AND METHODS

Between January 1991 and December 2005, 500 consecutive patients were referred to the Academic Medical Center (AMC) in Amsterdam for management of BDI after (laparoscopic) cholecystectomy and were induced in a database. Endoscopic and radiologic intervention was chosen in 349 patients (70%). A total of 151 patients (30%) who underwent reconstructive surgery were induced in this study. Patients' medical charts were retrospectively reviewed to analyze operation reports and clinical data, including type of the initial cholecystectomy (and subsequent relaparotomy), hospital stay, symptoms at referral, and diagnostic and therapeutic interventions, both from the referring center and the referral center. Follow-up data were obtained through regularly outpatient visits, and long-term outcome was obtained by mail and telephone surveys to the general practitioner and the referring surgeons.

### Patient Workup and Classification of BDIs

BDI was classified according to the Amsterdam classification<sup>17</sup>; in short: type A, cystic bile duct leakage; B, bile duct leakage; C, bile duct stricture and type D, bile duct transection. The location and involvement of the common hepatic duct were classified according to the Bismuth classification.<sup>18</sup> To investigate the influence of late referral on outcome, 2 categories of patients were defined. Primary referred patients did not undergo therapeutic interventions in the referring center. Secondary referred patients were referred after surgical, endoscopic, and radiologic interventions.

To investigate the influence of timing of repair on outcome, 3 groups of patients were defined. Group A consisted of patients operated within 6 weeks after the injury (ie, acute repair) and group B patients were operated after a minimum interval of 6 weeks (ie, delayed repair). Group C were patients who underwent previous treatment by reconstructive surgery or stenting and were referred after more than 6 weeks for the treatment of complications as anastomotic or ischemic strictures (ie, late repair). Outcome after reconstructive surgery was analyzed by the assessment of overall complications and surgery-related complications according to the classification of Dindo et al.<sup>19</sup> Complications specific for hepaticojejunostomy were defined as minor (eg, abscesses, wound infection and postoperative cholangitis) and major (eg, anastomotic leakage, postoperative bleeding, relaparotomy in the early postoperative period, and the development of anastomotic strictures).

### Surgical Treatment

Reconstruction was performed via a Roux-en-Y hepaticojejunostomy. Dissections starts toward the liver hilum and the bile duct remnant was identified when needed by division of the hilar plate as described by Couinaud and Bismuth and recommended by Blumgart.<sup>18,20</sup> In about half of the patients ( $n = 73$ , 48%) a percutaneous transhepatic catheter (10-F polyethylene) has been placed during the first hospital admittance for the management of persisting bile leakage or drainage of bile after a complete occlusion of the bile duct. This catheter could also be used as guiding probe for identification of the damaged duct in the hilum. The common hepatic and

left and right hepatic ducts were further mobilized and from there opened in particular to the left ducts of liver segment 2 and 3. The segmental ducts were sutured together, if possible, to enable the construction in one or 2 jejunal anastomoses. A closed suction drain is placed in Winslow and removed 24 to 48 hours after surgery. The transhepatic catheter, when inserted before surgery, was left behind in the jejunum loop in a transhepatic and transanastomotic position, and removed after 2 to 6 weeks, depending on the clinical course, the level of anastomosis, and the surgeons' preference. In all patients, the percutaneous catheter were removed with 6 weeks after surgery.

### Statistical Analysis

Comparison between groups was performed with a Student  $t$  test and  $\chi^2$  test. Fisher exact test was used when a table had a cell with an expected frequency of less than 5. Univariate analysis was first performed using a binary logistic regression to determine which variables were significantly associated with occurred complications. To identify independent predictors of major complications, variables identified as significant in univariate analysis were subsequently included in a stepwise logistic regression analysis. Data analyses were performed using SPSS software (SPSS, Chicago, IL). A  $P$  value of  $<0.05$  was considered statistically significant.

## RESULTS

### Patient Characteristics

The annual referral of BDI patients to the AMC and the number of reconstructions are summarized in Figure 1. Patient characteristics and classification of injury of 151 patients undergoing surgical repair are listed in Table 1. In 55 patients (36%), the laparoscopic procedure was converted after the occurrence of BDI. In 20 patients (13%), because a bile duct injury was identified during the laparoscopic procedure, others ( $n = 35$ , 23%) because of adhesions, acute inflammation, or bleeding. A bile duct transection (type D injury) was diagnosed in 122 patients (81%). In 40 patients (26.5%), the location of the injury was extended proximal of the bifurcation of the left and right hepatic duct (Bismuth classification IV and V). According to the American Society of Anesthesiologists (ASA) physical status classification, the majority of the patients ( $n = 132$ , 87%) was classified as ASA 1 or 2.

The referral pattern of the BDI patients is summarized in Table 2; the moment of diagnosis and the management prior to referral. The majority of patients ( $n = 87$ , 58%) were secondary referred and received surgical, endoscopic, or radiologic interventions in the referring hospital. In 1 patient, the injury occurred in the AMC, and this patient was therefore not defined as a referred patient. Immediate surgical repair was performed after conversion to an open procedure in 22 patients (15%), either by end-to-end anastomosis ( $n = 16$ ), roux-en-Y hepaticojejunostomy, or choledochoduodenostomy ( $n = 6$ ). Before referral, endoscopic treatment was performed in 10 patients (7%), transhepatic drainage in 8 patients (5%), and percutaneous drainage of fluid collections in 14 patients (9%).

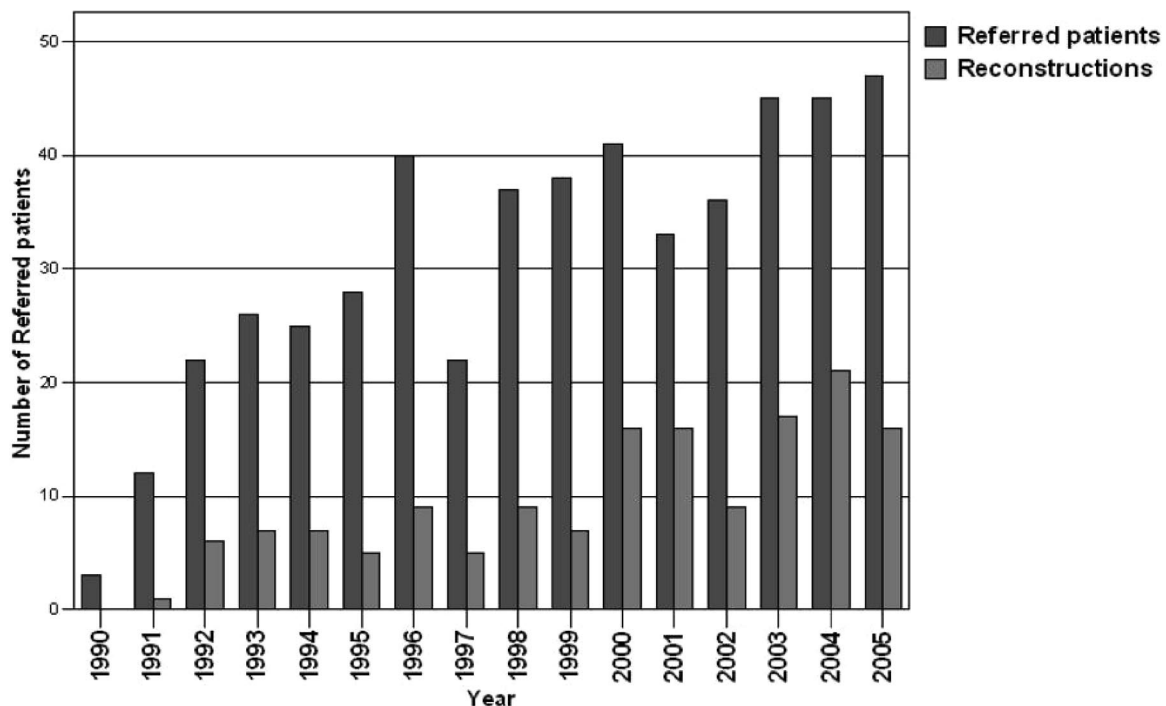


FIGURE 1. Year of referral and reconstructive procedures of patients with bile duct injuries.

TABLE 1. Patient Characteristics (n = 151)

| Demographics                                 | Value     | %    |
|--|-----------|------|
| Age (yr)                                     |           |      |
| Mean   | 48.2 ± 15 |      |
| Median                                       | 45        |      |
| Range  | 24–81     |      |
| Gender                                       |           |      |
| Female                                       | 101       | 67   |
| Initial procedure                            |           |      |
| Open cholecystectomy                         | 25        | 16.6 |
| Laparoscopic cholecystectomy                 | 71        | 47.0 |
| Laparoscopic cholecystectomy with conversion | 55        | 36.4 |
| Type of injury*                              |           |      |
| A, cystic duct leakage                       | 1         | 0.7  |
| B, leakage                                   | 13        | 8.6  |
| C, stricture                                 | 15        | 9.9  |
| D, transection                               | 122       | 80.7 |
| Level of injury†                             |           |      |
| Bismuth I–III                                | 111       | 73.5 |
| Bismuth IV–V                                 | 40        | 26.5 |
| ASA classification‡                          |           |      |
| ASA 1  | 44        | 29.1 |
| ASA 2  | 88        | 58.3 |
| ASA 3  | 17        | 11.3 |
| ASA 4  | 2         | 1.3  |

\*The type of injury is defined according to the Amsterdam classification.<sup>17</sup>

†The location of injury is defined according to the Bismuth classification.<sup>18</sup>

‡The American Society of Anesthesiologists (ASA) physical status classification.

Presenting symptoms of patients referred within 1 week after the cholecystectomy or later are summarized in Table 3. While symptoms of bile leakage and abscesses were the main presenting symptoms of BDI in patients referred within a week (60% vs. 31%,  $P = 0.003$ ; and 23% vs. 9%,  $P = 0.031$ ; respectively), cholangitis was the main symptom in patients referred after a week (32% vs. 13%,  $P = 0.04$ ).

TABLE 2. Time of Diagnosis, Referral Pattern, and Primary Interventions of Patients With Bile Duct Injury (n = 151)

|                                     | Value  | %    |
|-------------------------------------|--------|------|
| Moment of diagnosis                 |        |      |
| During cholecystectomy              | 34     | 22.5 |
| In-hospital                         | 62     | 41.1 |
| After discharge                     | 45     | 29.8 |
| Unknown                             | 10     | 6.6  |
| Primary referral                    | 63     | 41.7 |
| Secondary referral                  | 87     | 57.6 |
| Interventions in referring hospital |        |      |
| Initial repair                      | 22     | 14.6 |
| Relaparotomy with repair            | 17     | 11.2 |
| Explorative relaparotomy            | 11     | 7.3  |
| Percutaneous drainage               | 19     | 12.5 |
| ERCP stent/papilotomy               | 10     | 6.6  |
| PTD                                 | 8      | 5.3  |
| Time from injury to referral (days) |        |      |
| Median                              | 25     |      |
| Range                               | 0–4612 |      |

PTD indicates percutaneous transhepatic drain.

**TABLE 3.** Symptomatology in Bile Duct Injury Patients at Acute and Delayed Referral

|                                       | Referral<br><1 wk<br>(n = 30) |      | Referral<br>>1 wk<br>(n = 121) |      |
|---------------------------------------|-------------------------------|------|--------------------------------|------|
|                                       | Value                         | %    | Value                          | %    |
| Jaundice                              | 15                            | 50.0 | 72                             | 59.5 |
| Symptoms of bile leakage <sup>†</sup> | 18                            | 60.0 | 37                             | 30.5 |
| Cholangitis*                          | 4                             | 13.3 | 39                             | 32.2 |
| Abdominal pain <sup>†</sup>           | 16                            | 53.3 | 27                             | 22.3 |
| Abscess/biloma*                       | 7                             | 23.3 | 11                             | 9.1  |
| Uncontrolled sepsis/peritonitis       | 2                             | 6.6  | 5                              | 4.1  |

\* $P < 0.05$  ( $\chi^2$ ).<sup>†</sup> $P < 0.01$  ( $\chi^2$ ).

## Surgical Repair

The time from the initial operation to the reconstruction ranged from 1 to 4671 days (median, 115 days). Group A consisted of 15 patients (10%), group B of 96 patients (64%), and group C of 40 patients (26%). From the total of 15 patients undergoing surgery in the acute phase, 11 patients underwent the operation before 1999. Although no changes within the team of surgeons occurred in 1999, the principle of delayed reconstruction was applied more strictly. An interval period was introduced to first drain bile collections and let the inflammation subside. This change was influenced by bad experience in earlier years after semi-acute repair. From 1999 onwards, only 4 patients were operated in the acute phase. In these patients, the indication for repair in the acute phase was uncontrollable bile leakage (n = 2), a gauze that was left behind (n = 1), and optimal conditions for acute repair in the fourth patient. This last patient was referred directly after a complete transection below the bifurcation that was suspected perioperatively and shown on MRI within 6 hours after surgery. Conditions and patients were judged to be optimal to allow reconstruction by hepaticojejunostomy directly after referral.

## Short-term Outcome

Surgery related complications occurred in 29 patients (19%). The most common complications were abscess formation (n = 14; 9%), cholangitis (n = 9; 6%), and wound infection (n = 9; 6%). Severe complications included anastomotic leakage (n = 6; 4%) and an intra-abdominal bleeding (n = 1; 1%). A relaparotomy during hospital stay was performed in 7 patients because of deep abscess formation without successful percutaneous drainage (n = 5), anastomotic leakage (n = 1), and intra-abdominal bleeding (n = 1). Five patients with anastomotic leakage were successfully treated with a temporary percutaneous transhepatic stent. There was no hospital mortality. Postoperative complications, classified according to Dindo et al,<sup>19</sup> are summarized in Table 4.

## Long-term Outcome

Fourteen patients were lost in follow-up; 7 patients that were referred from abroad returned to the country of origin.

**TABLE 4.** Postoperative Complications According to Dindo et al<sup>19</sup> (n = 151)

| Grade | Value | %    |
|-------|-------|------|
| I     | 108   | 71.5 |
| II    | 12    | 7.9  |
| III   | —     | —    |
| IIIa  | 18    | 11.9 |
| IIIb  | 13    | 8.6  |
| IV–V  | 0     | —    |

The other 7 patients were lost in follow-up after 1 to 3.5 years of follow-up. All but one had an uncomplicated course until the loss of contact. One patient underwent a surgical repair of the hepaticojejunostomy due to a recurrent stricture. The mean follow-up was 5.3 years, median 4.5 years, ranging from 2 to 168 months. Six patients died during follow-up. In 2 patients, death was related to the bile duct injury. The first patient suffered from ERCP related pancreatitis and multiple biliodigestive fistulas after the BDI. He underwent various surgical procedures and died in the referring hospital due to sepsis. The second patient died due to hepatic failure probably due to recurrent anastomotic stricture, 10 years after the initial cholecystectomy and 5 repair procedures. Liver transplantation was not considered in this 70-year-old patient because of extreme alcohol abuse.

On long-term follow-up, anastomotic strictures were diagnosed in 15 patients (10%). These strictures were diagnosed with a mean interval of 46 months (median, 24 months; range, 8–120 months) after surgical repair. They presented with recurrent cholangitis (n = 8), cholestasis and abdominal pain (n = 4), and painless progressive cholestasis (n = 3). Three patients (2%) required surgical reconstruction and 12 (8%) were adequately treated by percutaneous transhepatic dilatation.

## Referral Pattern and Timing of Reconstruction

Short- and long-term results according to the referral pattern are shown in Table 5. Surgery-related complications were less frequent in primary referred patients (8% vs. 26%,  $P = 0.004$ ) and after long-term follow-up strictures were less frequent in patients with a primary referral (3% vs. 14%,  $P = 0.03$ ). The outcome is not explained by differences in patients' characteristics as age, gender, type of injury, location of injury, ASA classification, or duration of follow-up did not significantly differ between the 2 groups (data not shown). Short- and long-term results according to the timing of repair are shown in Table 6. Patients operated in the acute phase had more perioperative complications than patients operated in the delayed and late phase (33% vs. 16% and 23%,  $P = 0.22$ ). On the long-term, more strictures were diagnosed in patients who were operated in the acute phase (33% vs. 5% and 13%,  $P = 0.003$ ). Patients' characteristics in terms of age, gender, type of injury, location of injury, use for percutaneous catheters, and ASA classification did not significantly differ between the 3 groups (data not shown). The follow-up in

**TABLE 5.** Short- and Long-term Results of Reconstructions After BDI According to Referral Pattern

|   | Referral                |                           |
|---|-------------------------|---------------------------|
|   | Primary<br>(n = 63) (%) | Secondary<br>(n = 87) (%) |
| <b>Characteristics</b>                        |                         |                           |
| Age (yr) [mean (SD)]                          | 50 (14.6)               | 49 (14.9)                 |
| Gender, women (%)                             | 37 (58)                 | 63 (72)                   |
| ASA classification, ASA 1%–2%                 | 56 (89)                 | 75 (86)                   |
| Level of injury, Bismuth I–III (%)            | 50 (79)                 | 60 (69)                   |
| Preop. percutaneous transhepatic catheter (%) | 31 (49)                 | 42 (48)                   |
| <b>Short-term</b>                             |                         |                           |
| Patients with an overall complication         | 12 (19.0)               | 30 (34.4)*                |
| Patients with a surgery-related complication  | 5 (7.9)                 | 23 (26.4)*                |
| <b>Surgical complications</b>                 |                         |                           |
| Anastomotic leakage                           | 2 (3.1)                 | 4 (4.6)                   |
| Bleeding                                      | 0 (0)                   | 1 (1.1)                   |
| Abscess/biloma                                | 2 (3.1)                 | 11 (12.6)*                |
| Wound infection                               | 1 (1.5)                 | 8 (9.2)                   |
| Cholangitis                                   | 0 (0)                   | 8 (9.2)*                  |
| <b>Nonsurgical complications</b>              |                         |                           |
| Cardiopulmonary                               | 2 (3.1)                 | 3 (3.4)                   |
| Other miscellaneous                           | 2 (3.1)                 | 5 (5.7)                   |
| Reoperation initial stay                      | 0 (0)                   | 7 (8.0)*                  |
| In-hospital mortality                         | 0 (0)                   | 0 (0)                     |
| <b>Long-term</b>                              |                         |                           |
| Stricture formation                           | 2 (3.1)                 | 12 (13.8)*                |

\* $P < 0.05$  ( $\chi^2$ ).† $P < 0.01$  ( $\chi^2$ ).

patients operated in the acute phase was significantly longer because most of these patients underwent a reconstruction before 1999.

Results of univariate and multivariate analysis on major complications are shown in Table 7. In the univariate analysis, gender, ASA classification, previous repair, presence of fistula, and type of injury according to the Amsterdam classification were not associated with major complications. Younger age, extended proximal injury, late referral, and acute repair were associated with major complications. In patients under the median age of 45 years, more major complications occurred (odds ratio [OR] = 0.36; 95% confidence interval [CI], 0.14–0.94). Other predictive factors were extended proximal injury (Bismuth IV–V) (OR = 3.89; CI, 1.55–9.76), the secondary referral (OR = 3.84; CI, 1.23–12.00), and acute repair (OR = 5.73; CI, 1.63–19.47). A multiple stepwise logistic regression analysis identified 3 independent prognostic factors that were significantly associated with a higher risk of developing major complication: extended injury (OR = 3.70; CI, 1.32–10.34), secondary referral (OR = 4.35; CI, 1.12–16.76), and operating in the acute phase after the injury (OR = 5.44; CI, 1.2–24.43).

## DISCUSSION

The present study shows that reconstructive surgery for BDI in a tertiary center is associated with acceptable morbidity and no mortality. Extended proximal bile duct injuries, late referral to the tertiary center, and repair in the acute phase are 3 independent prognostic factors for worse outcome after reconstructive surgery for BDI. This study also shows the significant increase in the number of referred patients with BDI after LC over the past 15 years.

Since the introduction of LC, there has been extensive controversy about the incidence of BDI.<sup>3–7</sup> Shortly after the introduction, injury rates up to 2% were reported, while more recently there is a tendency to find lower rates around 0.2% to 0.3%.<sup>21–24</sup> The devastating results of the injury on long-term survival was described by Flum et al.<sup>1</sup> They showed a 3-fold increase in mortality during a follow-up period of 9 years in patients who underwent reconstructive surgery for BDI compared with patients without injury. The present study underlines the consequences of BDI as a healthcare problem, as these series showed a significant increase in referred patients in the last 15 years. This could be due to increased tendency to refer to a specialized center, as recommended earlier, but might also be caused by an increase of the severity of the injuries.<sup>1,25–27</sup>

In early referred patients, bile leakage and sepsis were diagnosed more often, while in patients referred after more than a week, obstructive jaundice and cholangitis were more frequent. Control of bile leakage and inflammation and visualization of the lesion level are the first steps in the management of BDI patients. Despite these principles, many patients underwent relaparotomy and early repair without further classification of the injury. Acute relaparotomy might be indicated in case of severe biliary peritonitis that cannot be managed by nonsurgical interventions, such as percutaneous drainage. It is recommended that drainage is performed by US- or CT-guided percutaneous procedures. Magnetic resonance cholangiopancreatography or endoscopic retrograde cholangiopancreatography can establish the diagnosis and can identify the extent of the injury, anatomic variations, and possible segmental lesions.

Previous reports showed that outcome after reconstructive surgery is poor when the injury extends above the bifurcation or involves the segmental ducts.<sup>12</sup> The present study provide further evidence of severe complications after injuries classified as Bismuth IV and V. Occlusions of isolated segmental ducts will exclude segments from drainage and leakage can cause hepatic abscess formation and recurrent cholangitis.

The detrimental effect of therapeutic interventions before referral to a tertiary center is illustrated in the present series. In this series, 58% of the patients were referred after previous interventions at the referring hospital, including surgical repair in 26%. Twenty-one percent of the patients referred after therapeutic interventions had a major complication after reconstructive surgery, while major complications occurred only in 6% of the patients who were referred primarily (Table 6). Quality of therapeutic endoscopy, interventional radiology, and reconstructive surgery are associated

**TABLE 6.** Short- and Long-term Results of Reconstructions After BDI According to Timing of Repair

|   | Timing                |                         |                      |
|---|-----------------------|-------------------------|----------------------|
|   | Acute<br>(n = 15) (%) | Delayed<br>(n = 96) (%) | Late<br>(n = 40) (%) |
| Characteristics                               |                       |                         |                      |
| Age (yr) [mean (SD)]                          | 45 (13.2)             | 50 (15.2)               | 47 (14.2)            |
| Gender, women (%)                             | 10 (67)               | 60 (63)                 | 31 (77)              |
| ASA classification, ASA 1%–2%                 | 12 (80)               | 84 (87)                 | 36 (90)              |
| Type of injury, A and B                       | 0 (0)                 | 8 (8)                   | 6 (15)               |
| Level of injury, Bismuth I–III (%)            | 9 (60)                | 71 (74)                 | 31 (77)              |
| Preop. percutaneous transhepatic catheter (%) | 6 (40)                | 52 (54)                 | 16 (40)              |
| Short-term                                    |                       |                         |                      |
| Patients with an overall complication         | 7 (46.7)              | 24 (25.0)               | 12 (30.0)            |
| Patients with a surgery-related complication  | 5 (33.3)              | 15 (15.6)               | 9 (22.5)             |
| Surgical complications                        |                       |                         |                      |
| Anastomotic leakage                           | 2 (13.3)              | 3 (3.1)                 | 1 (2.5)              |
| Bleeding                                      | 0 (0)                 | 0 (0)                   | 1 (1)                |
| Abscess/biloma                                | 4 (26.7)*             | 9 (9.3)                 | 1 (2.5)              |
| Wound infection                               | 0 (0)                 | 6 (6.2)                 | 3 (7.5)              |
| Cholangitis                                   | 2 (13.3)              | 3 (3.1)                 | 4 (10.0)             |
| Nonsurgical complications                     |                       |                         |                      |
| Cardiopulmonary                               | 1 (6.7)               | 3 (3.1)                 | 1 (2.5)              |
| Other miscellaneous                           | 2 (13.3)              | 4 (4.1)                 | 1 (2.5)              |
| Reoperation initial stay                      | 1 (6.7)               | 5 (5.2)                 | 1 (2.5)              |
| In-hospital mortality                         | 0 (0)                 | 0 (0)                   | 0 (0)                |
| Long-term                                     |                       |                         |                      |
| Stricture formation                           | 5 (33.3) <sup>†</sup> | 5 (5.2)                 | 5 (12.5)             |

\* $P < 0.05$  ( $\chi^2$ ).<sup>†</sup> $P < 0.01$  ( $\chi^2$ ).**TABLE 7.** Univariate and Multivariate Analysis on Major Complications

|                 | Major Complications<br>[no. (%)] | Univariate Analysis:<br>Odds Ratio (95% CI) | P                  | Multivariate Analysis:<br>Odds Ratio (95% CI) | P     |
|-----------------|----------------------------------|---|--------------------|---|-------|
| Age (yr)*       |                                  |   | 0.037 <sup>†</sup> |   | 0.07  |
| >45             | 7 (9.1)                          | —   |                    |   |       |
| <45             | 16 (21.6)                        | 0.36 (0.14–0.94)                            |                    | 0.37 (0.13–1.08)                              |       |
| Level of injury |                                  |   | 0.004 <sup>†</sup> |   | 0.012 |
| Low             | 11 (9.9)                         | —   |                    |   |       |
| High            | 12 (30.0)                        | 3.89 (1.55–9.76)                            |                    | 3.70 (1.32–10.34)                             |       |
| Referral        |                                  |   | 0.020 <sup>†</sup> |   | 0.033 |
| Primary         | 4 (6.3)                          | —   |                    |   |       |
| Secondary       | 18 (20.7)                        | 3.84 (1.23–12.00)                           |                    | 4.35 (1.12–16.76)                             |       |
| Timing repair   |                                  |   |                    |   |       |
| Delayed         | 10 (10.4)                        | —   |                    |   |       |
| Late            | 7 (17.5)                         | 1.82 (0.64–5.19)                            | 0.260              | 1.02 (0.31–3.33)                              | 0.968 |
| Acute           | 6 (40.0)                         | 5.73 (1.68–19.47)                           | 0.005 <sup>†</sup> | 5.44 (1.2–24.43)                              | 0.027 |

\*Median age was 45 years.

<sup>†</sup>Binary logistic regression.

Values in parentheses are percentages or 95% confidence intervals. Factors analyzed in univariate analysis that were not significant include gender, American Society of Anesthesiologist classification, previous repair, presence of fistula, placement of a preoperative percutaneous transhepatic catheter, and the type of injury according to the Amsterdam Classification.

CI indicates confidence interval; —, the reference variable.

with the outcome of treatment. Several authors advocate that patients who have to undergo complex hepatobiliary surgery should be referred to a specialized center.<sup>1,28–31</sup> Stewart and Way<sup>31</sup> showed that the outcome of a surgical repair after BDI is successful in 94% of the patients if performed in a specialized center, whereas only 17% is successful in patients operated by the initial surgeon.<sup>31</sup> Additionally, this study showed that the outcome for reconstructive surgery in a specialized center is influenced by the referral pattern. Short- and long-term outcome after reconstructive surgery is improved by adequate referral without therapeutic interventions in the center where the injury was caused.

This series also provides evidence for the hypothesis that surgical repair of BDI in the acute phase results in more complications. In the present analysis, the acute phase was defined within 6 weeks from the initial operation. Although most patients who underwent an acute repair were operated before 1999, no changes occurred in the team of hepatobiliary surgeons. A delayed repair was slowly introduced for patients with delayed detection, abscess formation, and inflammation. Because patients generally prefer early repair, we had to convince them for potential benefit of the delay. The principle of delayed reconstruction was applied more strictly since 1999. However, 2 of the 15 patients operated in the acute phase underwent a surgical repair within 2 days from the initial operation after 1999. In none of these patients did a surgical complication occur. Therefore, we think that a surgical reconstruction might also be performed shortly after the occurrence of the injury (within 2–3 days) if there is only obstruction without leakage or inflammation. Otherwise, the reconstruction should preferably be performed after an interval of approximately 6 weeks. This time interval is based upon the policy to reduce local inflammation and infection in the hepatoduodenal area and to drain abscesses and biloma. The findings in the present series correspond to the findings of Schmidt et al<sup>12</sup> who identified peritonitis at repair as an independent predictive factor on outcome. Ongoing inflammation is the plausible cause of complications in patients operated in the acute phase. Sicklick et al<sup>13</sup> reported that timing of repair did not affect outcome. However, looking in more detail in their series, the mean interval between the initial operation and the reconstruction was 42 weeks with a median of 10 weeks. This might partly be due to the referral pattern in the United States. This interval was also used to manage bile leakage, biliary fistula, or infected collections. The additional value of interventional radiology and stenting, before reconstruction, was again confirmed in the discussion in this article.<sup>13</sup> More evidence for their approach is provided by the present study.

## CONCLUSION

Reconstructive surgery for BDI in a tertiary center is associated with low morbidity and no mortality. The present study provides further evidence for the opinion that extended injuries have adverse influence on the outcome. Additionally, the current series also shows that referral after therapeutic interventions and repair in the acute phase have a detrimental effect on the short- and long-term outcome.

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